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Note

Moisture-dependent frictional and aerodynamic properties of safflower seeds

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A b s t r a c t. The seeds of two safflower cultivars were investigated in order to determine their frictional and aerodynamic properties as a function of moisture content. The coefficients of dynamic friction of cultivars on aluminium, plywood, fibreglass and steel surfaces increased by 87, 56, 78, and 129% for cv. Remzibey-05 seed, and by 91, 31, 71, and 131% for cv. Dinçer seed, respectively, between the initial and final moisture content levels. The terminal velocities of the Remzibey-05 and Dinçer seeds increased by 15 and 11%, respectively, with increase in moisture content between the initial and final levels.

K e y w o r d s: safflower seed, moisture content, frictional properties, aerodynamic properties

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an oilseed plant whose seed has recently gained importance in Turkey due to its seed oil. For instance, Turkey safflower production increased from 70 in 1990 to 7068 t in 2008 (FAOSTAT, 2010).

The friction coefficient of granular agricultural materials is a basic engineering parameter in the design of components related to storage structures, hoppers, conveyors, harvesters, and threshers. The frictional losses need to be overcome by providing additional power. Hence, the knowledge of coefficients of dynamic friction of agricultural products should be known. The angle of repose is necessary data in order to evaluate the flowability of granular agricultural products through hoppers. In order to move the seeds or grains in an airstream, terminal velocity is a design parameter for harvesters, conveyors, separators and cleaners.

Baümler *et al*. (2004), Gupta and Prakash (1992) and Seifi *et al.* (2010) studied some physical properties of safflower seeds. However, the terminal velocity and dynamic friction coefficient of safflower have not been investigated.

The aim of this study was to investigate the dynamic friction coefficients and terminal velocity of seeds of two safflower cultivars commercially grown in Turkey.

MATERIALS AND METHODS

Two safflower cultivars, namely, 'Remzibey-05' and 'Dinçer' were used in the experiments. The cultivars were obtained from the Southeast Anatolia Project Soil-Water Resources and Agricultural Research Institute, Şanlıurfa, Turkey. The seeds were cleaned by hand to remove foreign matter and broken seeds. The moisture content of the seeds was determined by the standard oven drying method at 105°C for 24 h (Solomon and Zewdu, 2009). The initial moisture content values of cvs.

The selected levels of moisture content of the seed are given in Table 1. The seed samples were kept in a refrigerator at 5°C, sealed in separate plastic bags for two weeks to enable the moisture to distribute uniformly throughout the sample. For all tests, the seeds were allowed to warm up to room temperature (Dursun *et al*., 2007).

The friction force was measured using a friction test device (Ozturk *et al*., 2009). The device consists of four main components: a square sample box, a friction surface driven by a mechanical driving unit, a load cell for sensing friction force, and a personal computer equipped with data acquisition board. The sample box was placed on the friction surface and filled with the seeds. A dead load of 10 kg was applied to the top of the seed sample and the friction surface was horizontally moved with the aid of a driving unit at a fixed sliding velocity of 24 mm min^{-1}. The friction force was sensed by the load cell connected to the sample box and the data were transmitted to the computer through a PCLD 770

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T a b l e 1. Moisture content levels of the safflower cultivars

Cultivar	Moisture content (d.b. mass)			
	M_{c1} (initial)	M_{c2}	M_{c3}	M_{c4}
Remzibey-05	5.79	10.11	14.37	19.05
Dinçer	5.07	9.45	14.69	19.16

signal conditioning board and a DACpad-71B data acquisition card and stored for subsequent off-line analyses. Four different friction surfaces, namely aluminium, plywood, fibreglass and steel were used in the tests. The friction tests were repeated three times.

The terminal velocity was determined using an air column. The measurement device consisted of three components. A vertical tube, a fan connected to a speed control and a hot wire digital anemometer with a probe. In order to homogenise the air flow and reduce the turbulence an airflow straightener made of teflon was placed in the vertical tube. A wire grid was positioned in the vertical tube to prevent the sample from falling down to the bottom. For each test, a small sample of seed was dropped into the air stream in the vertical tube and air was blown by a fan in the upward direction. Then the airflow rate was increased by the speed control unit until the sample was suspended in the vertical air stream. The probe of the hot wire anemometer was inserted into the air stream through a small hole in the wall of the tube and the air velocity near the location of the seed suspension was measured to an accuracy of 0.01 m s^{-1}. The procedure was replicated ten times and the average values were reported.

All the tests were conducted at the Biological Material Laboratory in the Agricultural Machinery Department of Ataturk University, Erzurum, Turkey.

RESULTS AND DISCUSSION

The variation of the coefficient of dynamic friction against aluminium, plywood, fibreglass and steel surfaces with increasing moisture content is shown in Fig. 1. As shown in these figures, the dynamic friction coefficient values of cv. Remzibey-05 seed on aluminium, plywood, fibreglass and steel surfaces increased from 0.23 to 0.43, from 0.16 to 0.25, from 0.23 to 0.41, and from 0.17 to 0.39, respectively, with increasing moisture content. Likewise, the dynamic friction coefficient values for cv. Dinçer seed increased from 0.22 to 0.42, from 0.16 to 0.21, from 0.21 to 0.36, and 0.16 to 0.37, respectively, with increase in moisture content. The values of dynamic friction coefficient of cv. Remzibey-05 seed were generally higher than those of cv. Dinçer seed.

a

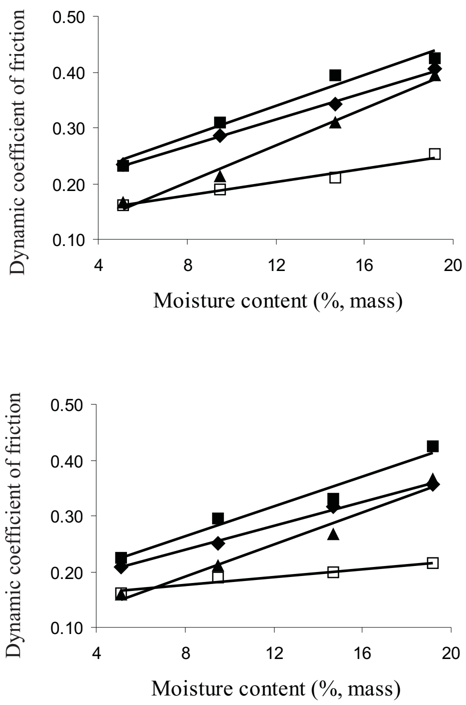

Fig. 1. Effect of moisture content on dynamic friction coefficient for: a – cv. Remzibey-05, b – cv. Dinçer seeds; ■ aluminium, □ plywood, ◆ fibreglass, ▲ steel.

In general, of the friction surfaces tested, aluminium exhibited the highest dynamic friction coefficient for both cultivars at all moisture content levels, followed by fibreglass, steel, and plywood surfaces. The rate of increase in the dynamic friction coefficient with increase in seed moisture content was the highest for the steel surface, followed by aluminium, fibreglass and plywood surfaces. On the other hand, the variation of the dynamic friction coefficient on the plywood surface as a function of moisture content was not so high as on the other surfaces. The dynamic friction coefficients of safflower seeds against the plywood surface were also found to be lower than those of lentil (Amin *et al*., 2004) and hemp seed (Sacilik *et al*., 2003). Those researchers reported that the dynamic friction coefficient of the product increased as the moisture content increased, supporting our results.

The increasing trend in the dynamic friction coefficient with increase of moisture content is due to increasing adhesion between seeds and frictional surfaces at higher moisture contents. It was observed that the moisture content had a higher effect on the dynamic friction coefficient than the friction surface did. Also, it was observed that the effect of moisture content on the dynamic friction coefficient was greater at higher moisture levels, possibly due to the seed being softer and therefore presenting a larger contact area between the seed and the friction surface.

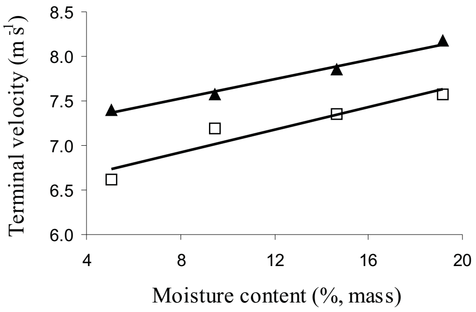

Fig. 2. Effect of moisture content on terminal velocity for safflower seeds: □ Remzibey-05, ▲ Dinçer.

The terminal velocities of safflower seeds obtained at selected moisture content levels are presented in Fig. 2 for both cultivars. Increase in moisture content from the initial level to the final one resulted in a considerable increase of terminal velocities of cvs. Remzibey-05 and Dinçer seeds, from 6.62 to 7.58 m s^{-1} and 7.39 to 8.17 m s^{-1}, respectively. The results reported by many researchers (Çalışır *et al*., 2005; Dursun *et al*., 2007; Sacilik *et al*., 2003; Yalçın, 2007; Yalçın *et al*., 2007) show that the terminal velocity of several seeds increased as the moisture content increased, supporting our results. On the other hand, the terminal velocity values for cv. Dinçer seed were higher as compared to those of cv. Remzibey-05 seed.

CONCLUSIONS

1. The coefficients of dynamic friction increased from 0.23 to 0.43, from 0.16 to 0.25, from 0.23 to 0.41, and from 0.17 to 0.39 on aluminium, plywood, fibreglass and steel surfaces, respectively, for Remzibey-05 seed with increase in moisture content.

2. The dynamic friction coefficients increased from 0.22 to 0.42, from 0.16 to 0.21, from 0.21 to 0.36, and 0.16 to 0.37 on aluminium, plywood, fibreglass and steel surfaces, respectively for cv. Dinçer seed as the moisture content increased.

3. The values of dynamic friction coefficient of cv. Remzibey-05 seed were generally higher than those of cv. Dinçer seed at all moisture content levels.

4. The values of terminal velocity of cvs. Remzibey-05 and Dinçer seed increased from 6.62 to 7.58 m s^{-1} and 7.39 to 8.17 m s^{-1}, respectively, as the moisture content increased.

5. The terminal velocity values for cv. Remzibey-05 seed were lower as compared to cv. Dinçer seed.

REFERENCES

Amin M.N., Hossain M.A., and Roy K.C., 2004. Effects of moisture content on some physical properties of lentil seeds. J. Food Eng., 65, 83-87.

Baümler E., Cunibert A., Nolasco S.M., and Riccobene I.C., 2004. Moisture dependent physical and compression properties of safflower seed. J. Food Eng., 72, 134-140.

Çalışır S., Marakoğlu T., Öğüt H., and Öztürk Ö., 2005. Physical properties of rapeseed (*Brassica napus oleifera* L.). J. Food Eng., 69, 61-66.

Dursun I., Tuğrul K.M., and Dursun E., 2007. Some physical properties of sugarbeet seed. J. Stored Products Res., 43, 149-155.

FAOSTAT**, 2010.** http://fao.org/ (June 03, 2010).

Gupta R.K. and Prakash S., 1992. The effect of seed moisture content on the physical properties of JSF-1 safflower. J. Oilseeds Res., 9(2), 209-216.

Ozturk I., Ercisli S., and Kara M., 2009. Chosen physical properties of olive cultivars (*Olea europaea* L.). Int. Agrophysics, 23, 309-312.

Sacilik K., Öztürk R., and Keskin R., 2003. Some physical properties of hemp seed. Biosystem Eng., 86(29), 191-198.

Seifi M. R., Alimardani R., Akram A., and Asakereh A., 2010. Moisture-depend physical properties of safflower (Goldasht). Advance J. Food Sci. Technol., 2(6), 340-345.

Solomon W.K. and Zewdu A.D., 2009. Moisture-dependent physical properties of niger (*Guizotia abyssinica* Cass.) seed. Industrial Crops Products, 29, 165-170.

Yalçın I., 2007. Physical properties of cowpea (*Vigna sinensis* L.) seed. J. Food Eng., 79, 57-62.

Yalçın I., Özarslan C. and Akbaş T., 2007. Physical properties of pea (*Pisum sativum*) seed. J. Food Eng., 79,731-735.